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Dated: Oct. 22, 2003

Signature: *[Signature]*

(Reza Mollaaghababa)

Docket No.: 101328-0151

(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Theodore H. Fedynyshyn

Application No.: 09/851,952

Group Art Unit: 1752

Filed: May 9, 2001

Examiner: Walke, Amanda C.

For: RESIST WITH REDUCED LINE EDGE
ROUGHNESS

**DECLARATION OF THEODORE H. FEDYNYSHYN
PURSUANT TO 37 C.F.R. 1.132**

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Dr. Theodore H. Fedynyshyn, a citizen of the United States residing at 32 Atkinson Lane, Sudbury, MA 01776, declare as follows:

1. I received a Ph.D. degree in Chemistry from Brown University in June 1980.
2. I have been employed as a senior scientist at Massachusetts Institute of Technology (MIT) Lincoln Laboratory at 244 Wood Street, Lexington, MA 02420 since October 1997. My responsibilities include conducting and supervising research in the area of resist chemistry, and in particular, in the area of novel resists suitable for use in high energy microlithography.
3. I am the inventor of the invention disclosed in the pending United States Patent Application No. 09/851,952 entitled "Resist With Reduced Line Edge Roughness," which was filed on May 9, 2001. I am familiar with the application and the prosecution conducted to date. In particular, I have studied a final Office Action issued on April 22, 2003 in this application.

4. It is my understanding that a number of claims in the patent application are rejected based on U.S. Patent No. 6,306,554 of Barclay and U.S. Patent No. 5,879,856 of Thackeray because the Examiner purports that a base to PAG molar ratio of 0.1 to 20 and 0.0212 to 0.42 can be inferred from Barclay and Thackeray, respectively.
5. I have performed experiments on photoresist compositions with a base to PAG molar ratios in a range of about 0.16 to about 20 to determine viability, and performance characteristics, of such compositions for use as positive photoresists, as described in more detail below.
6. The following resist compositions were prepared by employing a copolymer of p-hydroxystyrene and t-butyl acrylate with a monomer ratio of 60% p-hydroxystyrene and 40% t-butyl acetate as a resist polymer, di-t-butylphenyl iodonium camphor sulfonate (TBPI-CS) as a photoacid generator (PAG), and tetrabutyl ammonium hydroxide (TBAH) as a base.
7. A number of resists, described in Tables 1 and 2 below, were prepared by adding the resist polymer, the photo-acid generator (PAG) and the base in the amounts (in grams) listed below to 2757 parts of ethyl acetate solvent to generate a solution. The solution was rolled over night and filtered through a 0.2 micron filter.

Table 1.

Resist	Amount	Polymer	Amount	PAG	Amount	Base	Ratio B/P (molar)
99090	94	60:40	6	TBPI-CS	0.40	TBAH	0.160
99091	94	60:40	6	TBPI-CS	0.80	TBAH	0.321
99071	94	60:40	6	TBPI-CS	1.20	TBAH	0.481
99098	94	60:40	6	TBPI-CS	1.60	TBAH	0.642
99099	94	60:40	6	TBPI-CS	2.00	TBAH	0.802

Table 2

Resist	Amount	Polymer	Amount	PAG	Amount	Base	Ratio B/P (molar)
99176	94	60:40	6	TBPI-CS	5.0	TBAH	2.0
99177	94	60:40	6	TBPI-CS	12.5	TBAH	5.0
99178	94	60:40	6	TBPI-CS	25.0	TBAH	10.0
99179	94	60:40	6	TBPI-CS	37.5	TBAH	15.0
99180	94	60:40	6	TBPI-CS	50.0	TBAH	20.0

8. The resists were spin cast to an approximately 55 nm film on a HMDS vapor primed silicon wafer followed by a post apply bake (PAB) at about 140 C for approximately 60 seconds by placing the wafer on a hot plate. Development was accomplished by utilizing Shipley LLD-26W commercial resist developer. Each resist was exposed to 157 nm radiation at a series of different radiation doses ranging from 0 to 50 mJ/cm². After exposure, the wafer was PEB baked at about 130 C for approximately 90 seconds. The wafer was then immersed in a surfactant containing 2.38% aqueous solution of tetramethyl ammonium hydroxide for about 15 seconds. The wafer was then removed, rinsed with DI water, and dried under a stream of nitrogen gas.

9. For each resist, the clearing dose (E_0), defined as the lowest exposure dose required to remove all resist after development, was determined by either fitting a line through all points containing less than 80% normalized film thickness as a function of exposure dose and determining the intercept for the remaining film thickness to be zero, or if no slope could be determined, by noting the lowest exposure dose for which no resist remained. Further, for each resist, the unexposed film thickness loss (UFTL) was determined by subtracting the film thickness of an unexposed portion of the resist after development from the film thickness of the resist prior to exposure. The resolution for 157-nm imaging was determined by exposing the resist through a chrome on quartz mask containing dense features of 250, 200, 180, and 150 nm and determining the smallest feature that was printed. The values of line edge roughness (LER) were determined by measuring a 200 nm target feature at multiple locations on multiple lines and then determining the standard deviation of the linewidth. The

reported LER values were then obtained by dividing the corresponding standard deviation by two. The values of E_0 , and UFTL, and resolution and LER, where applicable, for the tested resist compositions are provided below in Tables 4 and 5 below.

Table 4

Resist	E_0 (mJ/cm ²)	UFTL (normalized)	Resolution (μm)	LER (nm)
99090	0.21	2.0	200	8.2
99091	0.25	1.7	200	<u>4.1</u>
99071	0.42	5.3	180	<u>4.0</u>
99098	0.71	3.8	180	<u>4.1</u>
99099	0.67	2.9	180	<u>2.0</u>

Table 5.

Resist	E_0 (mJ/cm ²)	UFTL (nm)	Pre-development Resist Thickness (nm)	Post-development Resist Thickness (nm)
99176	> 50	9.9	54.4	44.5
99177	> 50	12.2	53.2	41.0
99178	> 50	24.5	53.3	28.8
99179	> 50	> 59.1	59.1	0.0
99180	> 50	> 58.0	58.0	0.0

10. In general, values of LER for 157 nm imaging that are less than 5.0 nm are considered highly desirable and higher values are considered at best moderate or poor. The experimental data presented in Table 4 indicates that resist compositions having base to PAG ratios in a range of about 0.3 to 0.8 provide enhanced LER while Resist 99090 having a base to PAG molar ratio of 0.16 exhibits a much degraded LER of 8.2 nm.
11. The experimental data presented above in Table 5 indicates that the tested resist compositions with base to PAG ratios in a range of 2 to 20 are not capable of functioning as viable positive photoresists at 157 nm at lithographically useful

sensitivities. For example, Resists 99176, 99177, and 99178 exhibited a clearing dose (E_0) of greater than 50 mJ/cm^2 . Thus, even at the very high exposure dose of 50 mJ/cm^2 , some resist film remained on the wafer at the exposed areas. In other words, these resist compositions failed to image. Further, the above experimental data indicates that at higher base to PAG ratios of 15 and 20, the deleterious effects of high base concentration on lithographic properties of resist compositions exposed to 157 nm radiation are even more pronounced. For example, unexposed areas of Resists 99179 and 99180 were removed upon treatment with a base solution subsequent to exposure of the wafer to radiation. Thus, UFTL values associated with these resists are greater than about 60. In other words, these resists did not exhibit any differential resistance to base solubility between the exposed and unexposed portions, and hence are not suitable for patterning.

I further declare that all statements made herein of my knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

October 22, 2003

By: Theodore H. Fedynyshyn
Theodore H. Fedynyshyn

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